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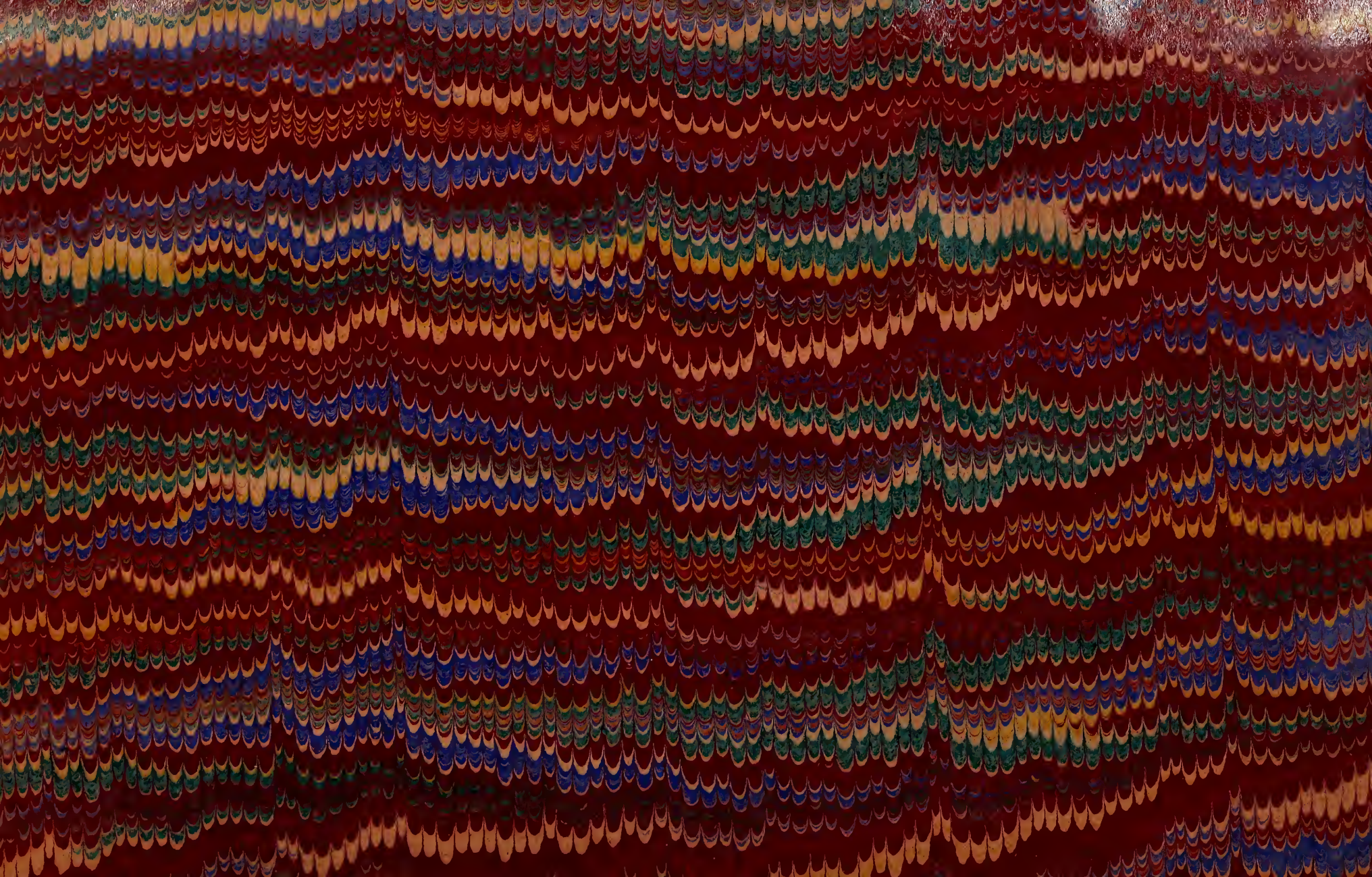

THE

Metric System.

DETAILED INFORMATION AS

TO LAWS, PRACTICE, ETC.

New York:

AMERICAN METROLOGICAL SOCIETY.

1891.

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CONCERT OF NATIONS.

1821.—Extracts from Report to House of Representatives, dated 22nd Feb., 1821, on Weights and Measures, by John Quincy Adams, then Secretary of State. House Doc. No. 109. 19th Cong., 2nd Sess.

"Perhaps when the spirit which urges to the improvement of the social condition of man, shall have made further progress against the passions with which it is bound, and by which it is trammelled, then may be the time for reviving and extending that generous and truly benevolent proposal of the constituent national assembly of France, and to call for a *concert* of civilized nations to establish one uniform system of weights and measures for them all." * * * * * * * * * * *

* * "Spain, Italy, the Netherlands, Denmark and Switzerland were actually represented in the proceedings of the Academy of Sciences to accomplish the purpose of the national assembly." * * * * * * * * * * * * *

* * "Two reports upon the whole result were made to the class, one by Trallés, of the Helvetic Confederation, the other by Van Swinden of the Netherlands, two of the foreign associates who had been invited to co-operate in the labor, and to participate in the honor of the undertaking. These two reports combined by Van Swinden into one, were then reported from the class to the general meeting of the institute, and by that body, with all suitable solemnity, to the two branches of the national assembly of France, on the 22nd of June, 1799, together with a definitive metre of platina, made by Lenoir, and a kilogramme of the same metal, made by Fortin." * * * * *

* * "The spectacle is at once so rare and so sublime, in which the genius, the science, the skill and the power of great confederated nations are seen joining hand in hand in the true spirit of fraternal equality, arriving in concert at one destined stage of improvement in the condition of human kind; that not to pause for a moment, were it even from occupations not essentially connected with it, to enjoy the contemplation of a scene so honorable to the character and capacities of our species, would argue a want of sensibility to appreciate its worth. This scene formed an epocha in the history of man."

1884.—The following table, translated from p. 162 of the published Proceedings of the International Committee of Weights and Measures for 1884, is dated at Paris, October 1, 1884, and signed by the President of the Committee, General Ibañez, of Spain, and the Secretary, Dr. Ad. Hirsch, of Switzerland. Its meaning is explained by Article 9 of the Metric Convention of 20th May, 1875, and Article 20 of the annexed regulations, from which it is seen that in the column of co-efficients, 3 means that the use of the metric system is *obligatory*; 2, *optional*; 1, *not yet legalized.*

Table of the shares to be contributed by the several states for the International Bureau of Weights and Measures for the year 1885.

	Contracting States.	Population.	Co-efficient.	Factor of Distribution.	Annual expenses, 100,000 francs. Unit 105 fr. 04 c. 2
1.	Germany	45,194,172	3	136	F. 14,286
2a.	Austria	20,136,283	3	60	6,303
2b.	Hungary	15,508,573	3	47	4,937
3.	Belgium	5,635,452	3	17	1,786
4.	Argentine Republic	2,000,000	3	6	630
5.	Denmark	1,980,675	1	2	210
6.	Spain	24,456,468	3	73	7,668
7.	United States of America	50,000,000	2	100	10,504
8.	France	42,403,892	3	127	13,340
9.	Great Britain and Ireland	35,172,976	2	70	7,353
10.	Italy	28,209,620	3	85	8,929
11.	Peru	2,699,945	3	8	840
12.	Portugal	5,400,000	3	16	1,681
13.	Roumania	5,000,000	3	15	1,576
14.	Russia	93,144,454	1	93	9,769
15	Servia	1,600,000	3	5	525
16a.	Sweden	4,577,783	2	9	945
16b.	Norway	1,900,000	3	6	630
17.	Switzerland	2,831,787	3	8	840
18.	Turkey	32,024,000	2	64	6,723
19.	Venezuela	1,784,194	3	5	525
	Total	421,660,274		952	100,000

Sweden's coefficient is now 3.
Japan has acceded to the Metric Convention of May 20, 1875.

METRIC CONVENTION OF MAY 20TH, 1875.

The following are articles translated from the convention signed at Paris, May 20th, 1875, by the plenipotentiaries of most of the leading governments of the world, the United States being one. It may be found in Vol. XX of the U. S. Statutes at Large, p. 709.

ARTICLE 1.

The high contracting parties engage to establish and maintain, at their common expense, a scientific and permanent international bureau of weights and measures, the location of which shall be at Paris.

ARTICLE 3.

The operation of the international bureau shall be under the exclusive direction and supervision of an international committee of weights and measures, which latter shall be under the control of a general conference for weights and measures, to be composed of the delegates of all the contracting governments.

ARTICLE 6.

The international bureau of weights and measures shall be charged with the following duties:

1st. All comparisons and verifications of the new prototypes of the metre and kilogram.

2nd. The custody of the international prototypes.

3rd. The periodical comparison of the national standards with the international prototypes and with their test copies, as well as comparisons of the standard thermometers.

4th. The comparison of the prototypes with the fundamental standards of non-metrical weights and measures used in different countries for scientific purposes.

5th. The standarding and comparison of geodesic measuring-bars.

6th The comparison of standards and scales of precision, the verification of which may be requested by governments or scientific societies, or even by constructors or men of science.

ARTICLE 9.

The entire expense of the construction and outfit of the international bureau of weights and measures, together with the annual cost of its maintenance and the expenses of the committee shall be defrayed by contributions from the contracting states, the amount of which shall be computed in proportion to the actual population of each.

REGULATIONS.

ARTICLE 7.

The general conference mentioned in article 3 of this convention shall be at Paris upon the summons of the international committee, at least once every six years.

It shall be its duty to discuss and initiate measures necessary for the dissemination and improvement of the metrical system, and to pass upon such new fundamental metrological determinations as may have been made during the time when it was not in session. It shall receive the report of the international committee concerning the work that has been accomplished, and shall replace one-half of the international committee by secret ballot.

The voting in the general conference shall be by states; each state shall be entitled to one vote.

Each of the members of the international committee shall be entitled to a seat at the meetings of the conference. They may at the same time be delegates of their governments.

ARTICLE 20.

The contributions referred to in article 9 of the convention shall be paid according to the following scale:

The number representing the population, expressed in millions, shall be multiplied by the co-efficient three for states in which the use of the metrical system is obligatory; by the co-efficient two for those in which it is optional; by the co-efficient one for other states. The sum of the products thus obtained will furnish the number of units by which the total expense is to be divided. The quotient will give the amount of the unit of expense.

ARTICLE 22.

These regulations shall have the same force and value as the convention to which they are annexed.

DIFFICULTY OF ADOPTING METRIC SYSTEM.

The one real objection to adopting the metric system is that to make any improvement in our accustomed practice is difficult and troublesome; it is very much easier to let things slide. This difficulty can be overcome in business in the United States, as it has been overcome in science in the United States, and in business in Europe and South America. As an example of the former, the metric system has been completely adopted within the memory of the present generation in chemistry, from which it naturally works into use in assaying, metallurgy, pharmacy and medicine. Examples of the latter are mentioned in the discussion on British and Metric Measures which took place in the Institution of Civil Engineers, London, January, 1885, as follows (Proceedings Inst. C. E., Vol. lxxx, Part II. Reprinted in *Van Nostrand's Engineering Magazine*, Vol. 33 for Sept.-Nov. 1885. See pp. 238, 241, 331, 388.)

Mr. Percival Fowler said, "he could speak from practical experience that in Spain, in a week, the workmen became thoroughly conversant with metres, centimetres, and millimetres, and he was certain that the difficulty of changing the English system of weights and measures to the decimal system had been greatly over-estimated."

Mr. Hamilton-Smythe said, "In Austro-Hungary, for instance, the metric system was extensively used by engineers for their own convenience for some years previous to its general introduction. It had become the interest of contractors and workmen to make themselves acquainted with the terms of measurement, in which the plans, specifications and bills of quantities supplied to them by their employers were expressed, and thus through the medium of the working class a knowledge of the system had been extensively spread through the mass of the people before the system was made legally compulsory for the purposes of general commerce."

"Mr. C. L. Hett remarked that in 1870 the Butterley Company obtained the contract for the Dordrecht Railway Bridge, and he had prepared the drawings for the steam cranes, scaffolding, etc., required in its erection. As the piling and superstructure of the staging had to be erected by a continental contractor, the drawings were made to metric measures. Drawing scales were ordered with the most generally used graduations on one edge, and corresponding metric divisions on the other. By the use of these scales all difficulty was overcome, and rapid progress made. The drawings of the bridge itself were prepared in Holland, under the supervision of the Dutch Government engineers, and were dimensioned in metric figures throughout. But in the works there was an outcry. The men at first said they could not, and would not work to such outlandish dimensions. The purchase of a few metric rules, however, settled the difficulty; and after a fortnight's practice, one of the old hands who had been most opposed to them, admitted that the metric measures were much the easiest to use." * * * "It should be mentioned that no member of the Butterly staff nor any of the workmen had had any previous experience of metric measures."

"Mr. F. Briffault pointed out two instances that had come under his notice in connection with two foreign water-works where the decimal and metric systems alone were used. The Brazilian Government had been supplied with 95,000 tons of pipes and connections from this country for the water-works of Rio de Janeiro, this quantity being divided between four manufactories. The castings were all weighed in kilograms, the weighing-machines having been made expressly for the purpose. At first the men did not take kindly to the innovation, but at the end of a fortnight, after finding out the great saving of trouble thereby effected, they much preferred this system to the British." * * * "In the case of the Constantinople water-works, similar satisfactory results had been obtained by the use of the decimal system; but in Turkey the advantage of it over the British system was even more marked." * * * "the reduced lengths were measured in metres and centimetres, and the maximum weight allowed per lineal metre being fixed, the two had but to be multiplied together, and the result was metric tons and decimal parts of the same."

REASONS FOR ADOPTING METRIC SYSTEM.

1. It is DECIMAL, and therefore (as is illustrated by the annexed example) it has the same advantage in arithmetic that decimal money has over British pounds, shillings and pence.

What are the contents in cubic feet and inches of a bin

8 ft. 4 in. long,
5 ft. wide,
and 2 ft. 5 in. deep?

8 ft. 4 in. = 100 inches.
5 ft. = 60 inches.

6,000
2 ft. 5 in. = 29 inches.

1728) 174,000 cu. in. (100
172,800

1,200

Answer:
100 cu. ft., and 1,200 cu. ins.

What are the contents in cubic meters and decimals of a bin

2½ meters long,
1.52 " wide, and
80 centimeters deep?

2.5
0.8

2.00
1.52

Ans. 3.04 cubic meters.

2. Its UNITS OF LENGTH BULK, WEIGHT, ETC., ARE SIMPLY RELATED TO EACH OTHER. This gives a great advantage over the irregularly related or unrelated old units (as shown by annexed example.)

Suppose a bin is to be filled with vegetables, grain or coal.

How many bushels does it hold if its cubical contents are 174,000 cubic inches?

There are 2,150.42 cubic inches in the U. S. bushel: but call it 2,150.

2150) 174000 (80.98 nearly.
1720

2000
1935

165

Answer:
81 bushels APPROXIMATELY.

How many hektoliters does it hold if its cubical contents are 3.04 cu. meters?

There are 10 hektoliters in a cubic meter; hence by moving decimal point one place we have

Answer, 30.4 hektoliters EXACTLY.

3. It is INTERNATIONAL, and intercourse between nations has increased so that it is now as important to have the same weights and measures used in different countries, as it was a century ago to have the same used in different parts of one country. Even non-metric nations afford illustrations of this.

For example:
The testing machine furnished by Riehlé Bros., of Philadelphia, for the Russian government arsenals at St. Petersburg, was graduated according to the metric system, 45,000 kilos on the main beam and 1,000 kilos on the small auxiliary beam.

The agreement between the United States and Great Britain, signed at Washington, June 18, 1880, for increasing the limits of magnitude of packets exchanged through the post between the two countries, uses the gram and centimeter, and contains no reference to any other unit of weight or measure. (U. S. Statutes at Large, v. 21, p.768)

The following is an extract from the report of the Congressional Committee on Coinage, Weights and Measures, Hon. Alex. H. Stephens, Chairman, printed in Report No. 53, H. of R., 45th Cong., 3rd Sess., and reprinted in Report No. 14, H. of R., 46th Cong., 1st Session.

"Indeed, the metric system has received the support of statesmen and the earnest sanction of scientists both in the New and the Old World for the past half century or more; and we cannot therefore longer treat with indifference the numerous appeals that are being made to Congress, from time to time, by the scientific and business men of the country, urging the adoption of the system in such departments of the government, at least, as have the largest relations with those countries and nations which have already adopted it in whole or in part, as an earnest of our purpose to adopt it in whole in all government transactions, so soon as our people are educated up to that point in its use that they will prefer the new to the existing system."

U. S. OFFICIAL REPORTS.

The following is an extract from the report of the Congressional Committee on Coinage, Weights and Measures, Hon. John A. Kasson, Chairman, printed in Report No. 62, H. of R., 39th Cong., 1st Sess., and reprinted in Report No. 14, H. of R., 46th Cong., 1st Session:

"Chambers of commerce, boards of trade, manufacturing associations, and other voluntary societies and individuals, will be induced to consider and in their discretion to adopt its use. The interest of trade among a people so quick as ours to receive and adopt a useful novelty will soon acquaint practical men with its convenience. When this is attained—a period, it is hoped, not distant—a further act of Congress can fix the date for its exclusive adoption as a legal system. At an earlier period it may be safely introduced into all public offices and for government service."

The following is an extract from the report of the Congressional Committee on Coinage, Weights and Measures, Hon. Alex. H. Stephens, Chairman, printed in Report No. 53, H. of R., 45th Cong., 3rd Sess., and reprinted in Report No. 14, H. of R., 46th Cong., 1st Session:

"From the survey we have been able to make of the more recent progress of this metrological reform in the more civilized and enlightened portions of the globe, we are irresistibly led to the conclusion that the metric system of weights and measures is destined to become in the near future universal among all the civilized nations of the world. Its adoption in the United States, and its obligatory use in all the government departments, is believed to be by many a fixed fact at no very distant day. As an earnest of this fact, we call your attention to the accompanying reports of the several heads of the executive departments of the government, as to the periods of time it would be advisable to adopt the system in their several bureaus."

The reports mentioned in the preceding sentence are referred to in the following article which appeared August 30, 1879, in ENGINEERING NEWS, Vol. VI, p. 278.

"The following tabular statement exhibits the estimates of various public officers as to the time required for the introduction of the metric system into branches of the government service where it is not yet used; but Gen. Meigs and Commissioner Williamson deprecate such introduction into their respective bureaus:

Time.	Department.	Officer.
Immediately	Post-office	F. V. Hayden, U. S. Geologist.
Long enough to distribute orders	Quartermaster's	M. C. Meigs, Q. M. General.
Long enough to furnish stand'rds	Navy	R. W. Thompson, Sec'y. of the Navy.
1 year	International commerce, postal service, unsurveyed public lands, internal revenue and government transportation	J. W. Powell, in Charge U. S. Geographical and Geological Survey, Rocky Mountain Region.
1 year	Ordnance	S. V. Benét, Chief of Ordnance.
1½ years	Post-office	D. M. Key, P. M. General.
Less than 2 years	Customs, postal system, coinage and all international transactions	Benj. Alvord, Paymaster General.
Less than 2 years	Postal purposes, coinage and customs	E. B. Elliott, Chief Clerk of Bureau of Statistics.
2 years	State	W. M. Evarts, Sec'y. of State.
2 years	All administrative transactions	J. K. Upton, Chief Clerk of Treasury Department.
3 years	General Land Office	J. A. Williamson, Commissioner of the General Land Office.
5 years	Engineer Corps	A. A. Humphreys, Chief of Engineers.
12 years	Customs and the collection of taxes upon spirits	J. E. Hilgard, in Charge U. S. Coast Survey Office."

3 millimeters, or other standard multiples or subdivisions of the centimeter. The convenience of the subjoined example lies in the fact that it has 8 millimeters to the ton, every 4 mm. representing 500 kilos (if the tons are metric), which lengths are well-known divisions of the ordinary metric rules and tapes.

SCALE OF TONS.

For the sake of bringing out clearly the fact that the convenience or inconvenience of a scale is independent of the magnitude of the real thing for which it stands, the example was chosen in which it stands for tons, as in diagrams for the graphical determination of stresses. These are not lengths. The more common use of scales upon plans is to stand for units of length. * *

* * * When it is length that is represented, a magnitude of the same nature as the scale itself, the scale may be designated by its ratio to the reality. * *

* * * With the metric system the units of length which scales most commonly stand for are the meter and the kilometer. For this use the same scales are convenient that are convenient for representing tons or anything else. * * * * *

* * * Since with the metric system the small divisions available for scales are all decimal parts of the meter, while all the larger units of length are decimal multiples of the meter, it follows mathematically that if it is the meter or larger unit of length which is represented, any reasonable scale must admit of being designated by a decimal fraction. A scale which cannot be designated decimally is not adapted to the metric linear measures.

Coast charts.						1/1000	.001 00	.001
Town maps.	60				88	1/1056	.000 94 69/99	To one kilometer.
Railways, canals, etc.					100	1/1200	.000 83 1/3	
Sectional plans of cities						1/1250	.000 80	.8
	40			8	132	1/1584	.000 63 13/99	
							.000 60	.6
	32			10	165	1/1980	.000 50 50/99	
						1/2000	.000 50	.5
				12	198	1/2376	.000 42 26/297	
					200	1/2400	.000 41 2/3	
						1/2500	.000 40	.4
	20			16	264	1/3168	.000 31 56/99	
							.000 30	.3
					300	1/3600	.000 27 7/9	
	16			20	330	1/3960	.000 25 25/99	
						1/4000	.000 25	.25
					400	1/4800	.000 20 5/6	
						1/5000	.000 20	.2
	12				440	1/5280	.000 18 23/66	
					500	1/6000	.000 166 2/3	
	10			32	528	1/6336	.000 157 82/99	
							.000 150	.15
					600	1/7200	.000 138 8/9	
	8			40	660	1/7920	.000 126 26/99	
						1/8000	.000 125	
					800	1/9600	.000 104 1/6	
						1/10000	000 100	.1
	6				880	1/10560	.000 094 69/99	
					1000	1/12000	.000 083 1/3	
						1/12500	.000 080	.08
	5			64	1056	1/12672	.000 078 181/198	
						1/15000	.000 066 2/3	
	4			80	1320	1/15840	.000 063 13/99	
							.000 060	.06
				100	1650	1/19800	.000 050 50/99	
						1/20000	.000 050	.05
	3				1760	1/21120	.000 047 69/198	
					2000	1/24000	.000 041 2/3	
						1/25000	.000 040	.04
	2 1/2			128	2112	1/25344	.000 039 181/396	
					2500	1/30000	.000 033 1/3	
	2			160	2640	1/31680	.000 031 56/99	
							.000 030	.03
				200	3300	1/39600	.000 025 25/99	
						1/40000	.000 025	.025
						1/50000	.000 020	.02
					5000	1/60000	.000 016 2/3	
	1		1	320	5280	1/63360	.000 015 155/198	
							.000 015	.015
						1/80000	.000 012 5	
						1/100000	.000 010 0	.01

A little study of the scales of plans shows that a series, each about 25 per cent. larger or smaller than the next, affords variety sufficient for all ordinary purposes. It is perplexing to have so many more sizes as are now in vogue. The trouble is due partly to awkward relations between English measures, and partly to diversity in the form of expressing scales.

It requires a mental effort, for example, to tell which is the larger, the architect's $\frac{3}{16}$ of an inch to the foot, or the engineer's 10 feet to an inch; on the other hand it is manifest that a scale of .015⅝ is nearly twice as large as a scale of .008⅓. As another illustration take 3 inches to the mile [$\frac{1}{21120}$.] a familiar phrase giving the space on map which represents a unit's distance on the ground. Reversing the form, the distance on the ground corresponding to a unit of map is 106⅔ rods to an inch; that is irregular; the old standard has been 100 rods to an inch [$\frac{1}{19800}$.] Not approving either of them the U. S. Coast Survey adopts the fractional expression $\frac{1}{20000}$. So far as magnitude is concerned, one of these would be as good as three, so nearly alike are they. The last is appropriately expressed as .00005 where a decimal system of measure is established; and there this scale can be used with equal convenience for larger and smaller scales by a simple change in pointing off decimal places. On the other hand, by the old practice, we have had for a smaller scale 3 miles to an inch [$\frac{1}{190080}$], which is one-ninth of $\frac{1}{21120}$, and for large scales 160 feet to an inch [$\frac{1}{1920}$], and $\frac{1}{16}$ of an inch to the foot [$\frac{1}{192}$] which are 11 times and 110 times $\frac{1}{21120}$. Here are five incongruous scales where one decimal scale would be enough.

The following tabular statement is intended to exhibit the most common scales in a clear form convenient for reference.

* * * The obvious way to secure a better state of things hereafter will be to use only scales in which there is some reason, and to abandon the numerous unreasonable ones. A reasonable scale is one whose

STANDARD SCALES.

Arranged for Comparison with Decimal Equivalents.

Use.	Customary. Number of inches to one mile.	Customary. Number of inches to one foot.	Customary. Length to one inch. Miles.	Rods.	Feet.	Fraction of full size. With 1 for numerator.	Fraction of full size. Decimal.	Metric. To one meter.
Working drawings of buildings, machinery, etc.		6				$\frac{1}{2}$	.500	.5
		3				$\frac{1}{4}$	.250	.25
						$\frac{1}{5}$	.200	.2
							.150	.15
		1½				$\frac{1}{8}$	.125	
						$\frac{1}{10}$	.100	.1
		1			1	$\frac{1}{12}$	.083⅓	
							.080	.08
		¾				$\frac{1}{16}$	.062½	
							.060	.06
						$\frac{1}{20}$	.050	.05
		½			2	$\frac{1}{24}$	.041⅔	
						$\frac{1}{25}$	.040	.04
		⅜				$\frac{1}{32}$	.031¼	
							.030	.03
		¼			4	$\frac{1}{48}$	.020⅝	
						$\frac{1}{50}$	.020	.02
		$\frac{3}{16}$				$\frac{1}{64}$	.015⅝	
							.015	.015
		⅛			8	$\frac{1}{96}$	.010$\frac{5}{12}$	
						$\frac{1}{100}$	.010	.01
					10	$\frac{1}{120}$	.008⅓	
						$\frac{1}{125}$	.008 0	.008
		$\frac{3}{32}$				$\frac{1}{128}$	.007 8⅛	
							.006 0	.006
		$\frac{1}{16}$			16	$\frac{1}{192}$	.005 2$\frac{1}{12}$	
						$\frac{1}{200}$	.005 0	.005
					20	$\frac{1}{240}$	.004 1⅔	
						$\frac{1}{250}$	.004 0	.004
							.003 0	.003
					30	$\frac{1}{360}$	.002 7$\frac{7}{9}$	
						$\frac{1}{400}$	.002 5	.0025
					40	$\frac{1}{450}$	.002 0$\frac{5}{9}$	
						$\frac{1}{480}$	.002 0	.002

Scientific American Supplement, No. 409, Saturday, June 14, 1879, and April 19, 1884.)

APPROXIMATE EQUIVALENTS,

(from the Journal of the Association of Engineering Societies, Vol. V. p. 226)

LENGTH.

1 inch	and	2 1-2	centimeters	(2.54)
1 foot	"	0.3	of meter	(.3048)
1 YARD	"	0.9	" METER	(.9144)
1 rod	"	5.	meters	(5.029)
1 chain	"	20.	"	(20.117)
1 furlong	"	200.	"	(201.17)
1 mile	"	1600.	"	(1609.3)

AREA.

1 sq. inch	and	6 1-4	sq.centim's	(6.451)
1 sq. foot	"	0.09	of sq. meter	(.0929)
1 sq. yard	"	0.81	" "	(.8361)
1 sq. rod	"	25.	sq. meters	(25.29)
1 rood	"	1000.	" "	(1011.7)
1 acre	"	0.4	of hektar	(.4047)
1 sq. mile	"	256.	hektars	(258.99)

BULK.

1 cubic inch	and	15 5-8	cubic centimeters	(16.387)
1 cubic foot	"	0.027	of cubic meter	(.028316)
1 cubic yard	"	0.729	" "	(.7645)
100 cubic feet	"	2.7	cubic meters	(2.8316)
(the unit of ship's measurement for register.)				
1 M board meas.	and	2 1-4	cubic meters	(2.36)
1 cord		and 3.6	cubic meters	(3.624)

WEIGHT.

		1 pound	and	0.45	of kilo	(.4536)
		60 lbs.(wheat bu.)	"	27.	kilos.	(27.216)
		80 lbs. (coal bu.)	"	36.	" .	(36.287)
1 grain	and .06 1-4	of gram		1 cental	"	45.	" .	(45.36)
1 troy oz.	" 30.	grams	(31.103)	112 lbs. (cwt.)	"	50.	" .	(50.8)
				1 NET TON	"	0.9	MET.TON	(.9072)
1 avoir.oz	" 27.	"	(28.35)	1 gross ton	"	1	" "	(1.016)

LIQUID MEASURE.

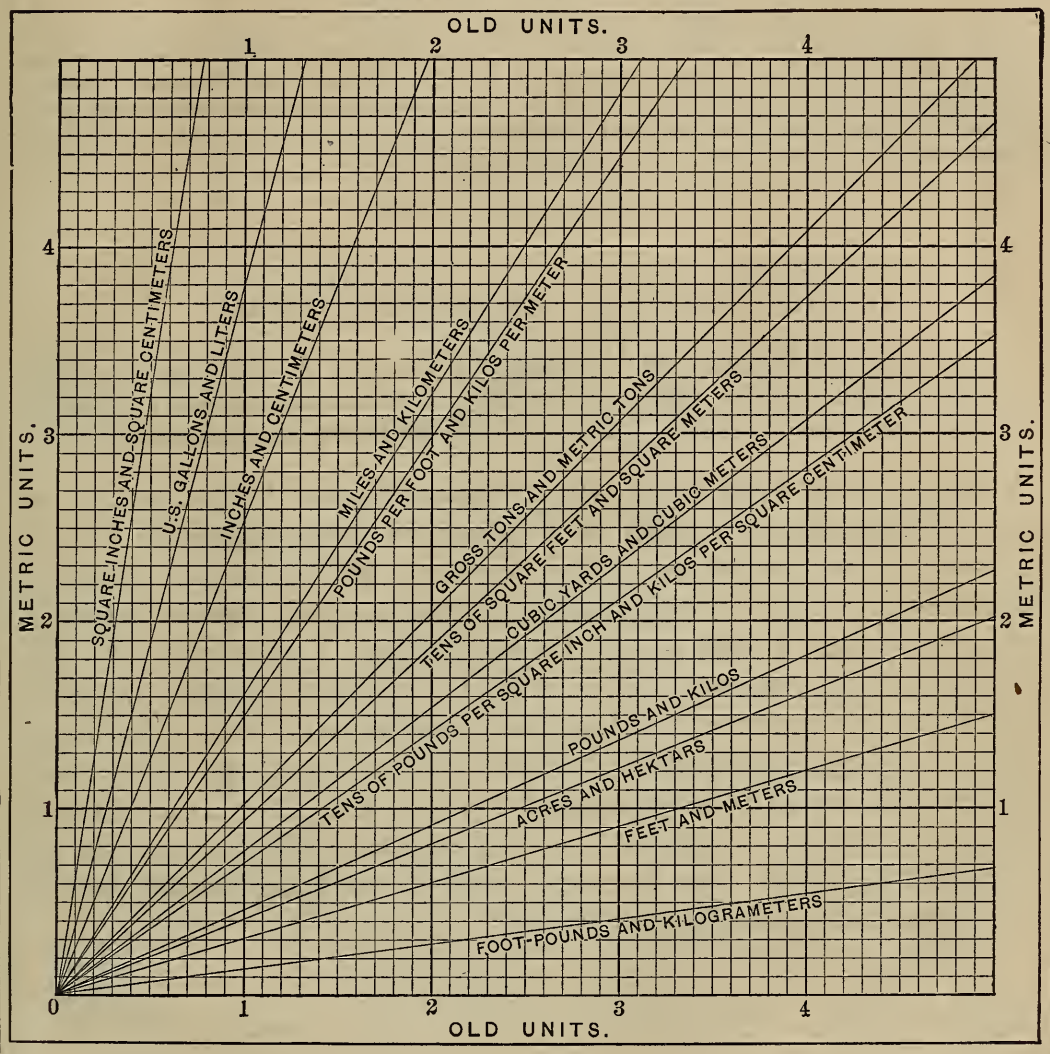
1 U. S. liq. pint	and	0.45	of liter	(.473)
1 " QUART	"	0.9	" LITER	(.946)
1 " gallon	"	3.6	liters	(3.785)
1 peck	"	9.	" (U. S. 8.81 Br. 9.08)	
1 bushel	"	36.	" (U.S. 35. 24 Br. 36.35)	
1 ton of ship's displacement	"	1	cubic meter	

COMBINATIONS.

	1 foot-ton (net)	and	0.27	of (metric) ton-meter	(.2765)	WEIGHT AND LENGTH
	1 foot-pound	"	0.13 1-2	of kilogrameter	(.13825)	
	1 pound per running yard	"	1-2	kilo per running meter	(.4961)	WEIGHT PER LENGTH
	1 " " " foot	"	1 1-2	kilos " " "	(1.4882)	
	1 pound per square foot	"	5.	kilos per square meter	(4.883)	WEIGHT PER AREA
About 1 atmosphere	1 net ton " " "	"	1	kilo per square centimeter	(0.9765)	
	15 lbs. " " inch	"	1	" " "	(1.0545)	
	1 pound " " "	"	0.07	" " "	(.07031)	
	1 net ton " " "	"	0.14	metric ton " "	(.14062)	
	1 pound per cubic foot	"	16.	kilos per cubic meter	(16.019)	WEIGHT PER BULK

DIAGRAM OF EQUIVALENTS.

(Adapted from a German periodical.)



OFFICIAL ABBREVIATIONS

(Extracted from ENGINEERING NEWS of April 8, 1882, and July, 8, 1882.)

LENGTH.		AREA.		BULK.		WEIGHT.	
Kilometer	km.	Sq. kilometer	km^2.	Ster	s.	Metric ton	t.
Meter	m.	Hektar	ha.	Cu. meter	m^3.	Metric quintal	q.
Decimeter	dm.	Ar	a.	Hektoliter	hl.	Kilogram	kg..
Centimeter	cm.	Sq. meter	m^2.	Dekaliter	dal.	Gram	g.
Millimeter	mm.	Sq. decimeter	dm^2.	Cu. decimeter	dm^3.	Decigram	dg.
Micron	μ.	Sq. centimeter	cm^2.	Liter	l.	Centigram	cg.
(=.001 m m.)		Sq. millimeter	mm^2.	Deciliter	dl.	Milligram	mg
				Centiliter	cl.	Microgram	γ.
				Cu. centimeter	cm^3.	(=.001 mg.)	
				Milliliter	ml.		
				Cu. millimeter	mm^3.		
				Microliter	λ.		
				(=.001 ml.)			

THE METRIC SYSTEM IN GOVERNMENT BUSINESS.

The metric system is already used in the U. S. Marine Hospital service, in the foreign business of the Post-office, in the U. S. Coast and Geodetic Survey, and to some extent in the Geological Survey, the Mississippi River Survey, the Mint, the international weather charts and bulletins of the U. S. Signal Service, and the reports of the U. S. Census of 1880. (See foot note about experiments on American woods, on p. 435 of Trautwine's Engineer's Pocket Book, 22nd thousand, 1885.)

MR. BLAINE ON THE METRIC SYSTEM.

The President, July 10, 1890, transmitted to Congress a letter from Secretary Blaine, accompanied by a report on weights and measures, unanimously adopted by the International American Conference. The Secretary, in his letter, says :

This report recommends the adoption by the United States of the metrical decimal system of weights and measures, which is now in use by the governments and people of all the other American republics and most of the nations of Europe, and which is already authorized by the laws of the United States. The adoption of this system in the customs service would, it is believed, greatly promote the public convenience, and I beg leave to submit for the consideration of Congress the draft of a bill for that purpose. The draft referred to reads : "Be it enacted, that on and after July 1, 1891, the metric system of weights and measures authorized by the act of Congress approved July 28, 1866, shall be used exclusively in the customs service of the United States."

The following is an extract from the report of the Congressional Committee on Coinage, Weights and Measures, Hon. John A. Kasson, Chairman, printed in Report No. 62, H. of R., 39th Cong., 1st Sess., and reprinted in Report No. 14, H. of R., 46th Cong., 1st Session.

"In concluding this review of the agitation of and action upon these questions in the United States, it only remains to add that the House of Representatives of the Thirty-eighth Congress, at its first session, established, by an amendment of its rules, a standing committee to take jurisdiction of this great reform. As efforts to carry that reform into effect had hitherto been spasmodic, rather than consecutive, it was thought proper thereafter to crystallize them through the action of a permanent committee, before whom they should perpetually reappear until this conceded great desideratum should become an accomplished fact."

That standing committee now has fourteen members, and ranks among the principal committees of the House. To it are referred all petitions for the introduction of the metric system. Any citizen who desires legislation as proposed, or otherwise, can send his petition to his representative, addressing House of Representatives, Washington, D. C., to be so referred.

REVISED STATUTES OF U. S. LEGALIZING METRIC SYSTEM.

SEC. 3569. It shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract or dealing, or pleading in any court, shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.

SEC. 3570. The tables in the schedule hereto annexed shall be recognized in the construction of contracts, and in all legal proceedings, as establishing, in terms of the weights and measures now in use in the United States, the equivalents of the weights and measures expressed therein in terms of the metric system; and the tables may lawfully be used for computing, determining, and expressing in customary weights and measures the weights and measures of the metric system.

MEASURES OF LENGTH.

Metric Denominations and Values.		Equivalents in Denominations in Use.
Myriameter	10,000 meters.	6 2137 miles
Kilometer	1,000 meters.	0.62137 mile, or 3,280 feet, 10 inches
Hectometer	100 meters.	328 feet, 1 inch.
Dekameter	10 meters.	393 7 inches.
Meter	1 meter.	39 37 inches.
Decimeter	1-10 of a meter.	3.937 inches.
Centimeter	1-100 of a meter.	0 3937 inch.
Millimeter	1-1000 of a meter.	0 0394 inch

MEASURES OF SURFACE.

Metric Denominations and Values.		Equivalents in Denominations in Use.
Hectare	10 000 square meters.	2.471 acres
Are	100 square meters.	119.6 square yards.
Centare	1 square meter.	1550 square inches

MEASURES OF CAPACITY.

Metric Denominations and Values.			Equivalents in Denominations in Use.	
Names.	Number of Liters.	Cubic measure.	Dry measure	Liquid or wine measure.
Kiloliter or Stere	1,000	1 cubic meter	1.308 cubic yards	264.17 gallons.
Hectoliter	100	1-10 of a cubic meter	2 bush and 3.35 pecks	26 417 gallons.
Dekaliter	10	10 cubic decimeters	9 08 quarts	2.6417 gallons.
Liter	1	1 cubic decimeter	0.908 quart	1.0567 quarts.
Deciliter	1-10	1-10 of a cubic decimeter.	6 1022 cubic inches	0.845 gill.
Centiliter	1-100	10 cubic centimeters	0 6102 cubic inch	0.338 fluid ounces.
Milliliter	1-1000	1 cubic centimeter	0.061 cubic inch	0 27 fluid drams.

WEIGHTS.

Metric Denominations and Values.			Equivalents in Denominations in Use.
Names.	Number of Grams	Weight of what quantity of water at maximum density.	Avoirdupois weight.
Millier or Tonneau	1,000 000	1 cubic meter	2204.6 pounds.
Quintal	100 000	1 hectoliter	220.46 pounds.
Myriagram	10 000	10 liters	22 046 pounds.
Kilogram or Kilo.	1,000	1 liter	2.2046 pounds.
Hectogram	100	1 deciliter	3.5274 ounces.
Dekagram	10	10 cubic centimeters	0.3527 ounce.
Gram	1	1 cubic centimeter	15.432 grains.
Decigram	1-10	1-10 of a cubic centimeter	1.5432 grains.
Centigram	1-100	10 cubic millimeters	0.1543 grain.
Milligram	1-1000	1 cubic millimeter	0 0154 grain.

(Approved July 28, 1866.)

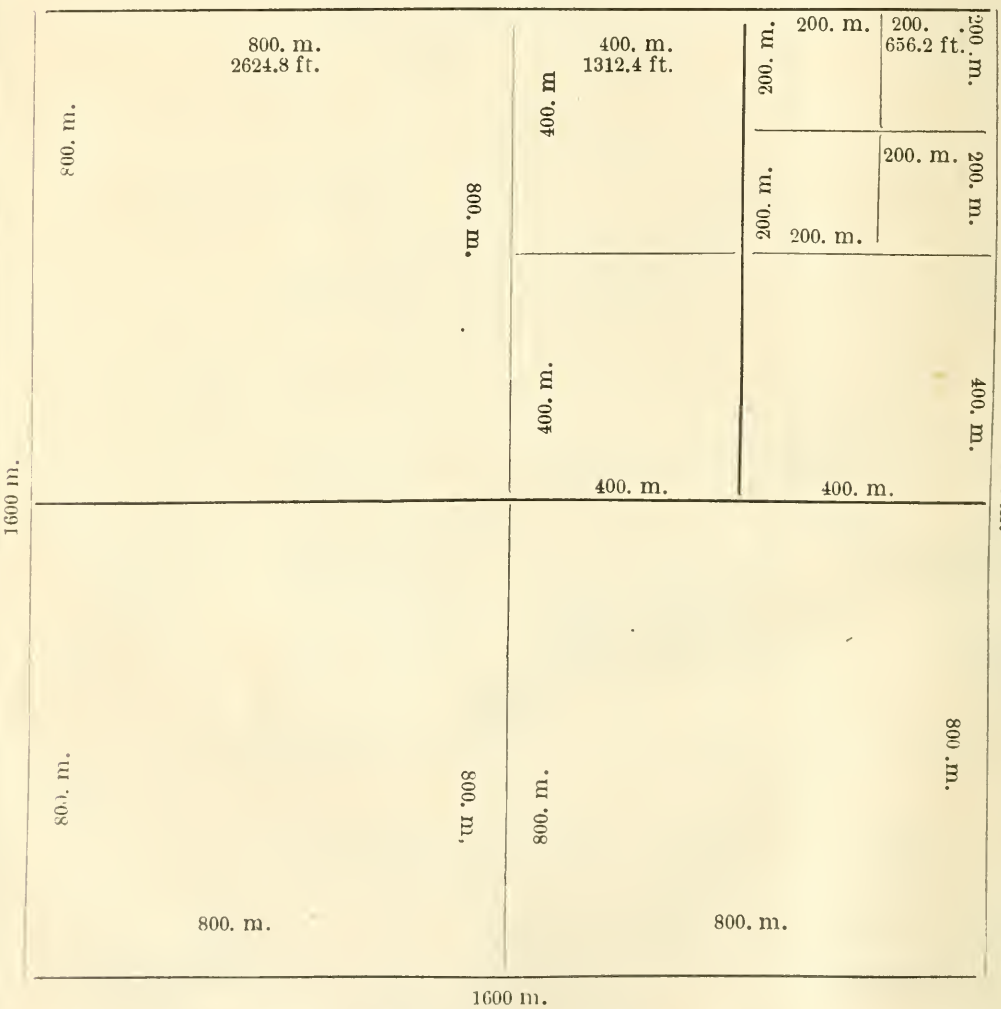
U. S. PUBLIC LAND SYSTEM.

In the report of the meeting, Nov. 6, 1878, of the Civil Engineers' Club of the Northwest (now Western Society of Engineers) is the following, which is in substance identical with the presentation of the subject that has been made by various other persons.

"Mr. GREELEY then gave a blackboard illustration of the method of applying the Metric System to the U. S. system of survey of public lands, and their division into sections.

The simplest form of a section of land, and the one most nearly approximating to our mile section would be the rectangle of 1,600 metres for the section, or the equivalent of 5249.6 feet; that divided into quarters would give 800 metres for the quarter; that divided again would be 400; and that again into the sixty-fourths, which is the smallest division known to the government, would be 200 metres. The difference between the 1,600 metres—5,429, and the mile 5,280, is only about 31 feet and a fraction, which is considerably less than the allowed limit of error in our government surveys."

PLAT SHOWING THE BINARY SUBDIVISION OF A METRIC SECTION OF LAND.



The Metric System in Surveying.

Information about the use of the metric system in surveying, illustrated by diagrams of implements used, etc., has been published as follows:

In *Van Nostrand's Engineering Magazine*, Vol. XX, p. 380 (May, 1879), Report of Committee on Metric System to Boston Society of Civil Engineers, presented March 19, 1879.

In *Journal of the Association of Engineering Societies*, Vol. II, pp. 321-328 (Dec. 1883), papers presented to Boston Society of Civil Engineers, Dec. 19, 1883.

METRIC RAILWAY CURVES.

The table below was printed in ENGINEERING NEWS October 13th, 1883, and modifications of it were published in the 1885 editions of Henck's Field-Book for Railroad Engineers (p. 273) and Trautwine's Civil Engineer's Pocket-Book (p. 728.) *Use 20-meter chords.* Stakes 20m. apart want to be designated by alternate numbers as 2, 4, 6, 8, etc., making the dekameter the unit of numeration, and marking each kilometer with an exact hundred. Designate curvature by the angle at circumference subtended by 20 m. chords ("tangential" angle of Trautwine and Shunk, "deflection" angle of Henck and Searles,) which is the same as the central angle subtended by the unit of numeration. Length of curve according to stake-numbering, if multiplied by this designating angle, gives the total change of direction made by the curve.

20 M. CHORD ANGLE.	Minutes to be laid off per meter.	RADIUS IN METERS.	Logarithm of radius.	DEFLECTION		Middle ordinate at distance from end of chord	Quarter point ordinate at distance from end of chord	Length in meters of ARC of designated number of degrees.	20 M. CHORD ANGLE.
				from tangent.	from chord.	of 10 m.	of 5 m.		
0° 10′	0½′	3437.75	3.5362745	.058	.116	.015	.011	10.0000	0° 10′
20′	1′	1718.88	3.2352463	.116	.233	.029	.022	10.0001	20′
30′	1½′	1145.93	3.0591581	.175	.349	.044	.033	10.0001	30′
40′	2′	859.46	2.9342237	.233	.465	.058	.044	10.0002	40′
50′	2½′	687.57	2.8373192	.291	.582	.073	.055	10.0004	50′
1° 0′	3′	572.99	2.7581447	.349	.698	.087	.065	10.0005	1° 0′
10′	3½′	491.14	2.6912059	.407	.814	.102	.076	10.0007	10′
20′	4′	429.76	2.6332231	.465	.931	.116	.087	10.0009	20′
30′	4½′	382.02	2.5820810	.524	1.047	.131	.098	10.0011	30′
40′	5′	343.82	2.5363351	.582	1.163	.145	.109	10.0014	40′
50′	5½′	312.58	2.4949553	.640	1.280	.160	.120	10.0017	50′
2° 0′	6′	286.54	2.4571808	.698	1.396	.175	.131	10.0020	2° 0′
10′	6½′	264.51	2.4224340	.756	1.512	.189	.142	10.0024	10′
20′	7′	245.62	2.3902659	.814	1.629	.204	.153	10.0028	20′
30′	7½′	229.26	2.3603204	.873	1.745	.218	.164	10.0032	30′
40′	8′	214.94	2.3323107	.931	1.861	.233	.175	10.0036	40′
50′	8½′	202.30	2.3060020	.989	1.977	.247	.186	10.0041	50′
3° 0′	9′	191.07	2.2811998	1.047	2.093	.262	.196	10.0046	3° 0′
10′	9½′	181.03	2.2577414	1.105	2.210	.276	.207	10.0051	10′
20′	10′	171.98	2.2354889	1.163	2.326	.291	.218	10.0056	20′
30′	10½′	163.80	2.2143247	1.222	2.442	.306	.229	10.0062	30′
40′	11′	156.37	2.1941477	1.280	2.558	.320	.240	10.0068	40′
50′	11½′	149.58	2.1748701	1.338	2.674	.335	.251	10.0075	50′
4° 0′	12′	143.36	2.1564155	1.396	2.790	.349	.262	10.0081	4° 0′
10′	12′½	137.63	2.1387167	1.454	2.906	.364	.273	10.0088	10′
20′	13′	132.35	2.1217146	1.512	3.022	.378	.284	10.0095	20′
30′	13′½	127.45	2.1053567	1.570	3.138	.393	.295	10.0103	30′
40′	14′	122.91	2.0895961	1.629	3.254	.407	.306	10.0111	40′
50′	14½′	118.68	2.0743911	1.687	3.370	.422	.317	10.0119	50′
5° 0′	15′	114.74	2.0597040	1.745	3.486	.437	.328	10.0127	5° 0′
20′	16′	107.58	2.0317513	1.861	3.718	.466	.349	10.0145	20′
40′	17′	101.28	2.0055032	1.977	3.950	.495	.371	10.0163	40′
6° 0′	18′	95.67	1.9807654	2.093	4.181	.524	.393	10.0183	6° 0′
20′	19′	90.65	1.9573751	2.210	4.413	.553	.415	10.0204	20′
40′	20′	86.14	1.9351943	2.326	4.644	.582	.437	10.0226	40′
7° 0′	21′	82.06	1.9141055	2.442	4.875	.612	.459	10.0249	7° 0′
20′	22′	78.34	1.8940076	2.558	5.106	.641	.481	10.0274	20′
40′	23′	74.96	1.8748128	2.674	5.336	.670	.503	10.0299	40′
8° 0′	24′	71.85	1.8564447	2.790	5.567	.699	.525	10.0326	8° 0′
20′	25′	69.10	1.8388361	2.906	5.797	.729	.547	10.0353	20′
40′	26′	66.36	1.8219279	3.022	6.027	.758	.569	10.0382	40′
9° 0′	27′	63.92	1.8056676	3.138	6.257	.787	.591	10.0412	9° 0′
20′	28′	61.66	1.7900083	3.254	6.487	.816	.613	10.0444	20′
40′	29′	59.55	1.7749082	3.370	6.717	.846	.635	10.0476	40′
10° 0′	30′	57.59	1.7603298	3.486	6.946	.875	.657	10.0510	10° 0′

THE IMPERIAL STANDARD WIRE GAUGE (below) was established by the British Government from March 1, 1884, (and mentioned in ENGINEERING NEWS, Vol. XI, p. 101 for March 1, 1884), but the best practice is to specify wire by diameter or weight, disregarding gauge numbers. The following is copied from Appendix No. 3 to the Weights and Measures Report, dated August 5, 1884, made to Parliament by the Board of Trade, which also gives inch values:

Descriptive Number.	Diameter in Centimeters.	Section in Square Centimeters.
No.		
7-0	1.2700	1.2667
6-0	1.1785	1.0909
5-0	1.0973	0.9456
4-0	1.0160	.8107
3-0	0.9449	.7012
2-0	.8839	.6136
0	.8229	.5319
1	.7620	.4560
2	.7010	.3858
3	.6401	.3218
4	.5893	.2727
5	.5385	.2277
6	.4877	.1868
7	.4470	.1570
8	.4064	.1297
9	.3658	.1051
10	.3251	0.08302
11	.2946	6818
12	.2642	5480
13	.2337	4289
14	.2032	3243
15	.1829	2627
16	.1626	2075
17	.1422	1589
18	.1219	1167
19	.1016	0.008107
20	0.0914	6566
21	813	5188
22	711	3972
23	610	2922
24	559	2452
25	508	2027
26	457	1641
27	0.04166	1363
28	3759	1110
29	3454	0.0009372
30	3150	7791
31	2946	6818
32	2743	5910
33	2540	5067
34	2337	4289
35	2134	3575
36	1930	2927
37	1727	2343
38	1524	1824
39	1321	1370
40	1219	1167
41	1118	0.0000982
42	1016	811
43	0.00914	656
44	813	519
45	711	397
46	610	292
47	508	203
48	406	129
49	305	0.0000073
50	254	507

MISCELLANEOUS UNITS.

	KILOMETERS.
1 Admiralty knot is	1.853
1 grade ($\frac{1}{100}$ of quadrant or 0° 54′ sexagesimal)	
of longitude on equator is	100.2
of latitude at equator is	99.5
of " " pole "	100.5
" " (mean length) is	100.0
Earth's circumference (meridional)	40007.5

" polar semi-axis 6,356.515 meters.

" equatorial semi-diameter 6,378,249 meters.

ratio 292.465 : 293.465

(according to last portion of Col. A. R. Clarke's article *Geodesy* in Encyclopaedia Brittanica, 9th Ed. vol. X, p. 172).

Earth's radius in round numbers, 6,360 kilometers.

1 atmosphere is the pressure of a column of 76 centimeters of mercury at the temperature of melting ice at Paris, where it is equal to 1.0333 kilos on a square centimeter.

	At sea level.		
	At equator.	At pole.	Taken as
Acceleration of gravity in meters per second...	9.7810	9.8311	9.81
Length of seconds pendulum in meters.....	0.99103	0.99610	0.99396

C. G. S. units of Committee of British Association for the Advancement of Science.

FORCE.—The *dyne* is the force which, acting upon a gram of matter for a second, generates a velocity of a centimeter per second.

WORK.—The *erg* is the work done by this force acting through a centimeter

POWER.—The unit is the power of doing work at the rate of one *erg* per second. The *watt* is the power of doing work at the rate of 10,000,000 ergs per second.

Varying with gravity the weight of a kilogram is about 981,000 *dynes*; the kilogrameter is about 98,100,000 *ergs*; and the horse power is about 7,460,000,000 *ergs* per second, or is about 746 *watts*. The dynamical equivalent of a unit of heat, or the work required to warm 1 gram of water from 0° to 1° centigrade, is 41,553,000 *ergs*, or about 0.4235 of a kilogrameter.

For ELECTRICAL measurements, the Centimeter, Gram and Second are adopted as the fundamental units. The resistance known as 1 *ohm* is intended to be 1,000,000,000 absolute electro-magnetic units, and therefore is represented by a velocity of 1,000,000,000 centimeters (one earth quadrant) per second. The *legal ohm* was fixed by international convention in April, 1884, as the resistance of a column of mercury 1 square millimeter in cross-section and 106 centimeters long at the temperature of melting ice.

EXTRACTS FROM THE REPORT OF T. C. MENDENHALL, SUPERINTENDENT U. S. COAST AND GEODETIC SURVEY, TO SECRETARY OF STATE, SEPTEMBER 16, 1889.

* * Three of the South American states, namely, the Argentine Confederation, Peru, and Venezuela, are now parties to the convention of 1875 establishing the Bureau.

* * A common system of weights and measures has been legalized throughout Central and South America, and it cannot be doubted, since its use has been made obligatory by the principal South American states, that it will prevail there to the exclusion of all other systems.

* * * * * * * * * *

In concluding this report the following recommendations are submitted for consideration :

That the Congress shall recommend—

(1) That the desirability of promoting the establishment of an International System of Weights and Measures be recognized as a principle of action in legislation.

(2) That the decimal or metric system shall serve as the basis of unification.

(3) That all nations not already parties to the Convention signed at Paris, May 20, 1875, establishing an International Bureau of Weights and Measures, shall become parties thereto.

(4) That the aggregate statistics of International Commerce shall be, where it is not yet being done, published also in metric equivalents.

(5) That all invoices shall be made out in metric weights and measures, where weights and measures appear, as far as they relate to the commerce between the nations participating in this Congress, and that the above table * of equivalents shall be recognized as legal by the nations taking part in this Congress in converting the customary weights and measures of the United States into metric weights and measures in making such invoices.

(6) That metric weights be used exclusively in the mints.

RESOLUTIONS PASSED BY THE A. A. A. S.

Resolved, That the American Association for the Advancement of Science desires respectfully to call the attention of the United States Congress, in both branches, to the favorable consideration of the introduction into the tariff measures now pending, of a statement of all items of weight or measure in terms of the metric, as well as of the ordinary system.

That the Association also most earnestly indorses the resolution already introduced, and now awaiting the action of Congress, recommended by the Pan-American Congress, providing that the metric system be exclusively used in the Custom Houses of the United States after July 1, 1891.

That the said measures will constitute a powerful auxiliary in familiarizing the people with the use of the metric system, and in reinforcing the previous efforts in that direction so favorably regarded by previous Congresses.

That the Association feels that in these recommendations it has the cordial support of intelligent and educated men in all portions of the Union, irrespective of political party or opinion.

That a copy of these resolutions be forwarded to the Chairman of the Senate and the Speaker of the House, the Chairman of the Finance Committee and the Chairman of the Committee of Ways and Means.

A. A. A. S., Indianapolis, Aug., 1890.

* See page *L.*

DRAWN 1880 FOR AMERICAN METRIDLOGICAL SOCIETY 49TH ST. AND 4TH AVE NEW YORK CITY.

OBJECTS ARE SHOWN OF NATURAL SIZE, PAPER WILL VARY SLIGHTLY WITH MOISTURE.

METRIC SYSTEM

LEGALIZED FOR OPTIONAL USE BY U.S.A., GREAT BRITAIN AND POSSESSIONS, NOT BY RUSSIA NOR MONTENEGRO; ADOPTED IN PART BY KINGDOMS OF DENMARK AND GREECE AND AS A WHOLE BY THE REST OF EUROPE AND POSS'NS AND THE OTHER AMERICAN GOVERNMENTS.

MILLI-MEANS	.001
CENTI- "	.01
DECI- "	.1
DEKA- "	10.
HEKT- "	100.
KILO- "	1000.
MYRIA- "	10 000.

LENGTH

(ABOUT ONE SIDE OF A TOWNSHIP) 1 THOUSANDTH OF THE EARTH'S QUADRANT OR 10000 METERS MAKE 1 MYRIA-METER.
(ROUGHLY 10 MINUTES WALK) 1000 METERS MAKE 1 KILO-METER.
100 METERS MAKE 1 HEKTO-METER.
10 METERS MAKE 1 DEKA-METER.

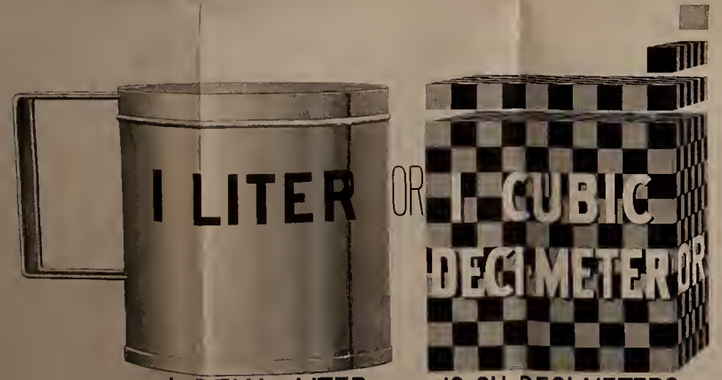
AREA

1 SQ. MYRIA-METER IS 10000 HEKT-ARS (ABOUT A TOWNSHIP OF U.S. PUBLIC LAND SYSTEM)
1 SQ. KILO-METER IS 100 HEKT-ARS
1 SQ. HEKTO-METER IS 1 HEKT-AR OR 100 ARS (ROUGHLY THE AREA OF A BASE BALL FIELD)
1 SQ. DEKA-METER OR 100 SQ. METERS, IS 1 AR

1 METER

10 DECI-METERS
100 CENTI-METERS

1000 MILLI-METERS



1 CUBIC CENTI-METER OF WATER WEIGHS 1 GRAM
10 " " " " " " 10 "
100 " " " " " " 100 "

IN U.S. SUBSIDIARY SILVER COIN THE WEIGHT OF $0.04
" " " " " " " " $0.40
" " " " " " " " $4.00

BULK

1000 CU. CENTI-METERS

WEIGHT

" " " $40.00

1 DEKA-LITER " 10 CU. DECI-METERS " 10 000 " " " " " 10 000 " "10 KILOS OR 1 MYRIA-GRAM
(ABOUT THE BULK OF A BARREL) 1 HEKTO-LITER " 100 " " " " 100 000 " " " " " 100 " " 1 METRIC QUINTAL (ROUGHLY THE WEIGHT OF A BARREL OF FLOUR)
1 STER OR 1 KILO-LITER OR 1 CUBIC METER "1000 " " " "1000 000 " " " OF WATER WEIGHS 1000 " " 1 METRIC TON OR 1 TONNEAU OR 1 MILLIER

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